

CLAIM AMENDMENTS

Please amend the claims by amending claims 78, 90, 96, 99, 101, 107, 110, 116, 119, and 129, all without prejudice, as indicated on the following listing of all the claims in the present application after this Amendment:

1. – 77. (Cancelled.)

78. (Currently Amended) A method of obtaining overlay measurements for a semiconductor wafer, the method comprising:
forming a periodic grating on the wafer having:
a first set of gratings,
wherein the first set of gratings are formed on the wafer using a first mask, and
a second set of gratings,
wherein the second set of gratings are formed on the wafer using a second mask,
wherein the first and second sets of gratings are ~~intended to be~~ formed on the wafer with
an ~~intended~~ asymmetrical alignment ~~when the first mask and second mask are in alignment~~;
measuring a diffraction signal of the first and second sets of gratings after the first and
second sets of gratings are formed on the wafer; and
determining a misalignment between the first and second sets of gratings formed on the
wafer based on the measured diffraction signal.

79. (Previously presented) The method of claim 78, wherein the measured diffraction signal is a zero-order diffraction.

80. (Previously presented) The method of claim 79, wherein only the zero-order diffraction is measured.

81. (Previously presented) The method of claim 78, wherein the diffraction signal is measured using an optical metrology system.

82. (Previously presented) The method of claim 81, wherein the optical metrology system includes an ellipsometer.

83. (Previously presented) The method of claim 81, wherein the optical metrology system includes a reflectometer.

84. (Previously presented) The method of claim 78, wherein the diffraction signal is measured using an incident signal with a normal incidence angle.

85. (Previously presented) The method of claim 78, wherein the diffraction signal is measured using an incident signal with an oblique incidence angle.

86. (Previously presented) The method of claim 85, wherein the incident signal has an azimuthal angle of zero degrees.

87. (Previously presented) The method of claim 85, wherein measuring the diffraction signal includes:

measuring the amplitude of the diffraction signal.

88. (Previously presented) The method of claim 78 further comprising:
generating a set of diffraction signals for a range of possible misalignments between the first and second sets of gratings,
wherein each diffraction signal in the set corresponds to a different possible misalignment within the range of possible misalignments.

89. (Previously presented) The method of claim 88 further comprising:
generating a response curve of the correspondence between the different possible misalignments of the first and second sets of gratings and the set of diffraction signals.

90. (Currently Amended) The method of claim 88 further comprising:
determining the ~~intended~~ asymmetric alignment between the first and second sets of gratings based on the generated set of diffraction signals and range of possible alignments.

91. (Previously presented) The method of claim 88, wherein the set of diffraction signals are generated empirically.

92. (Previously presented) The method of claim 88, wherein the set of diffraction signals are generated using modeling.

93. (Previously presented) The method of claim 88, wherein the determining the misalignment between the first and second sets of gratings comprises:
comparing the measured diffraction signal to the generated set of diffraction signals; and
determining the possible misalignment that corresponds to the diffraction signal from the generated set of diffraction signals that matches the measured diffraction signal.

94. (Previously presented) The method of claim 78,
wherein the first and second sets of gratings include a plurality of ridges that repeat at a periodic interval, and
wherein the ridges of the first and second sets of gratings alternate.

95. (Previously presented) The method of claim 94,
wherein the ridges of the first and second sets of gratings include centerlines having a spacing between the centerlines of the ridges of the first and second sets of gratings, and
wherein the first and second sets of gratings are symmetrically aligned when the spacing between the centerlines is uniform and asymmetrically aligned when the spacing between the centerlines is non-uniform.

96. (Currently Amended) The method of claim 95, wherein the ~~intended~~ asymmetric alignment includes an offset from symmetrical alignment of the first and second sets of gratings.

97. (Previously presented) The method of claim 78, wherein the first and second sets of gratings include a plurality of ridges that repeat at a periodic interval, and wherein the ridges of the second set of gratings are formed on the ridges of the first set of gratings.

98. (Previously presented) The method of claim 97, wherein the ridges of the first and second sets of gratings include centerlines, and wherein the first and second sets of gratings are symmetrically aligned when the centerlines of the ridges of the first and second sets of gratings are aligned and asymmetrically aligned when the centerlines are not aligned.

99. (Currently Amended) The method of claim 98, wherein the ~~intended~~ asymmetric alignment includes an offset from symmetrical alignment of the first and second sets of gratings.

100. (Previously presented) The method of claim 78, wherein forming a periodic grating on the wafer comprises:

- forming a periodic grating in a first metrology field on the wafer;
- forming a periodic grating in a second metrology field on the wafer,
- wherein the first and second metrology fields are separated by a distance on the wafer;
- obtaining overlay measurements from the first and second metrology fields; and
- computing an error based on the obtained overlay measurements.

101. (Currently Amended) A method of obtaining overlay measurements for a semiconductor wafer using a periodic grating, the method comprising:

- forming a first set of gratings of the periodic grating on the wafer;
- forming a second set of gratings of the periodic grating on the wafer,
- wherein the first and second sets of gratings are formed using separate masks, and

wherein the second set of gratings are ~~intended to be~~ formed on the wafer with an ~~intended~~ asymmetrical alignment from the first set of gratings ~~when the separate masks are in alignment~~;

generating a set of diffraction signals for a range of possible misalignments between the first and second sets of gratings,

wherein each of the diffraction signal in the generated set of diffraction signals corresponds to a possible misalignment between the first and second sets of gratings;

measuring a diffraction signal of the first and second sets of gratings after the first and second sets of gratings are formed on the wafer,

wherein the diffraction signal is measured; and

determining a misalignment between the first and second sets of gratings based on the measured diffraction signal and the generated set of diffraction signals.

102. (Previously presented) The method of claim 101, wherein the determining the misalignment between the first and second sets of gratings comprises:

comparing the measured diffraction signal to the generated set of diffraction signals; and

determining the possible misalignment that corresponds to the diffraction signal from the generated set of diffraction signals that matches the measured diffraction signal.

103. (Previously presented) The method of claim 101, wherein the measured diffraction signal is a zero-order diffraction.

104. (Previously presented) The method of claim 101 further comprising:

generating a plurality of sets of diffraction signals at various wavelengths and/or polarizations.

105. (Previously presented) The method of claim 101,

wherein the first and second sets of gratings include a plurality of ridges that alternate with a spacing between the ridges,

wherein the first and second sets of gratings are symmetrically aligned when the spacing between the ridges of the first and second sets of gratings is uniform and asymmetrically aligned when the spacing is non-uniform.

106. (Previously presented) The method of claim 101, wherein the first and second sets of gratings include a plurality of ridges with centerlines, wherein the ridges of the second set of gratings are formed on the ridges of the first set of gratings, and

wherein the first and second sets of gratings are symmetrically aligned when the centerlines of the ridges of the first and second sets of gratings are aligned and asymmetrically aligned when the centerlines are not aligned.

107. (Currently Amended) A method of obtaining overlay measurements for a semiconductor wafer using a periodic grating formed on the wafer, the method comprising:

obtaining the wafer, wherein the period grating on the wafer comprises:

a first set of gratings that were formed on the wafer using a first mask,

a second set of gratings that were formed on the wafer using a second mask,

wherein the first and second sets of gratings were ~~intended to be~~ formed on the wafer with an asymmetric alignment ~~when the first mask and second mask are in alignment;~~

generating a set of diffraction signals for a plurality of possible misalignments between the first and second sets of gratings;

measuring a diffraction signal of the first and second sets of gratings from the obtained wafer,

wherein the diffraction signal is measured, and

wherein the measured diffraction signal is a zero-order diffraction;

comparing the measured diffraction signal to the generated set of diffraction signals; and

determining an amount and direction of misalignment between the first and second sets of gratings on the obtained wafer based on the possible alignment that corresponds to the diffraction signal from the set of diffraction signals that matches the measured diffraction signal.

108. (Previously presented) The method of claim 107,
 wherein the periodic grating on the wafer further comprises:
 a first periodic grating oriented for obtaining overlay measurements in a first coordinate
 direction, and
 a second periodic grating oriented for obtaining overlay measurements in a second
 coordinate direction; and
 wherein measuring a diffraction signal further comprises:
 measuring a first diffraction signal from the first periodic grating, and
 measuring a second diffraction signal from the second periodic grating without rotating
 the wafer.

109. (Previously presented) The method of claim 108, wherein the measured
 diffraction signals and the generated diffraction signals have amplitude ratios, and wherein the
 amplitude ratios of the measured diffraction signals are compared with the amplitude ratios of
 the generated diffraction signals.

110. (Currently Amended) The method of claim 108, wherein the diffraction signals
 are measured using an oblique ~~and conical~~ incident signal.

111. (Previously presented) The method of claim 107, wherein the diffraction signal
 is measured using a normal incidence angle.

112. (Previously presented) The method of claim 107, wherein the diffraction signal
 is measured using an oblique incidence angle with an azimuthal angle.

113. (Previously presented) The method of claim 107, wherein the diffraction signal
 is measured using an oblique incidence angle with an azimuthal angle of zero degrees.

114. (Previously presented) The method of claim 107,

wherein the first and second sets of gratings include a plurality of ridges that alternate with a spacing between the ridges,

wherein the first and second sets of gratings are symmetrically aligned when the spacing between the ridges of the first and second sets of gratings is uniform and asymmetrically aligned when the spacing is non-uniform.

115. (Previously presented) The method of claim 107,
wherein the first and second sets of gratings include a plurality of ridges with centerlines,
wherein the ridges of the second set of gratings are formed on the ridges of the first set of gratings, and

wherein the first and second sets of gratings are symmetrically aligned when the centerlines of the ridges of the first and second sets of gratings are aligned and asymmetrically aligned when the centerlines are not aligned.

116. (Currently Amended) A system to obtain overlay measurements of a semiconductor wafer, the system comprising:

a periodic grating formed on the wafer comprising:

a first set of gratings formed using a first mask,

a second set of gratings formed using a second mask, and

wherein the first and second sets of gratings are ~~intended to be~~ formed with an asymmetric alignment ~~when the first mask and second mask are in alignment~~; and

an optical metrology system comprising:

a detector configured to measure a diffraction signal from the first and second sets of gratings, and

a signal processing unit configured to determine a misalignment between the first and second sets of gratings based on the measured diffraction signal.

117. (Previously presented) The system of claim 116, wherein the signal processing unit is configured to compare the measured diffraction signal to a set of diffraction signals generated for a plurality of possible alignments between the first and second sets of gratings.

118. (Previously presented) The system of claim 116, wherein the periodic grating further comprises:

a first periodic grating oriented in a first coordinate direction; and
a second periodic grating oriented in a second coordinate direction,
wherein overlay measurements can be obtained in the first and second coordinate directions using the first and second periodic gratings without rotating the wafer.

119. (Currently Amended) The system of claim 118, wherein the optical metrology system comprises:

a source configured to produce an oblique ~~and conical~~ incident signal.

120. (Previously presented) The system of claim 116, wherein the optical metrology system comprises:

a source configured to produce a normal incident signal.

121. (Previously presented) The system of claim 116, wherein the optical metrology system comprises:

a source configured to produce an incident signal having an oblique incidence angle and an azimuthal angle of zero degrees.

122. (Previously presented) The system of claim 116, wherein the periodic grating comprises:

a first portion with the first and second sets of gratings having a first alignment; and
a second portion with the first and second sets of gratings having a second alignment.

123. (Previously presented) The system of claim 122,
wherein the detector is configured to measure a first diffraction signal from the first portion of the period grating and a second diffraction signal from the second portion of the periodic grating, and

wherein the signal processor is configured to determine the amount and direction of misalignment between the first and second sets of gratings based on the measured first and second diffraction signals.

124. (Previously presented) The system of claim 123, wherein the signal processor is configured to determine the alignment of the first and second sets of gratings by comparing the difference between the measured first and second diffraction signals to a set of difference signals generated for a plurality of possible misalignments between the first and second sets of gratings.

125. (Previously presented) The system of claim 123, wherein the periodic grating further comprises:

- a third portion having only the first set of gratings; and
- a fourth portion having the second set of gratings.

126. (Previously presented) The system of claim 125, wherein the optical metrology system comprises:

a library of simulated-diffraction signals having a set of theoretical geometry of the first and second sets of gratings;

wherein the detector is configured to measure a diffraction signal from the third portion and a diffraction signal from the fourth portion; and

wherein the signal processing unit is configured to compare the measured diffraction signal to the simulated-diffraction signals to determine the geometry of the first and second sets of gratings.

127. (Previously presented) The system of claim 116, wherein the first and second sets of gratings include a plurality of ridges that alternate with a spacing between the ridges; and wherein the first and second sets of gratings are symmetrically aligned when the spacing between the ridges of the first and second sets of gratings is uniform and asymmetrically aligned when the spacing is non-uniform.

128. (Previously presented) The system of claim 116, wherein the first and second sets of gratings include a plurality of ridges with centerlines; wherein the ridges of the second set of gratings are formed on the ridges of the first set of gratings; and wherein the first and second sets of gratings are symmetrically aligned when the centerlines of the ridges of the first and second sets of gratings are aligned and asymmetrically aligned when the centerlines are not aligned.

129. (Currently Amended) A method to obtain overlay measurements for a semiconductor wafer, comprising:

measuring a diffraction signal of a first set of grating and a second set of gratings of a periodic grating formed on the wafer, wherein

the first set of gratings were formed using a first mask,

the second set of gratings were formed using a second mask, and

wherein the first and second sets of gratings were ~~intended to be formed on the wafer with an asymmetric alignment when the first mask and second mask are in alignment;~~

generating a set of diffraction signals for a plurality of possible misalignments between the first and second sets of gratings;

determining a misalignment of the first and second sets of gratings formed on the wafer based on the measured diffraction signal and the generated set of diffraction signals; and

130. (Previously presented) The method of claim 129, further comprising:
obtaining the geometry of the first set of gratings; and
obtaining the geometry of the second set of gratings,
wherein the generated set of diffraction signals is generated based on the obtained geometry of the first and second sets of gratings.

131. (Previously presented) The method of claim 130, further comprising:
measuring diffraction signals of the first set of gratings;
measuring diffraction signals of the second set of gratings; and

comparing the measured diffraction signals to a library of simulated-diffraction signals having a set of theoretical geometry of the first and second sets of gratings.

132. (Previously presented) The method of claim 131, wherein the diffraction signals of the first set of gratings are measured from a third portion of the grating having only the first set of gratings, and the diffraction signals of the second set of gratings are measured from a fourth portion of the grating having the second set of gratings.

133. (Previously presented) The method of claim 129, further comprising:
measuring a first diffraction signal from a first periodic grating;
determining the amount and direction of misalignment between the first and second sets of gratings in a first coordinate direction using the first measured diffraction signal;
measuring a second diffraction signal from a second periodic grating without rotating the wafer; and
determining the amount and direction of misalignment between the first and second sets of gratings in a second coordinate direction using the second measured diffraction signal.

134. – 204. (Cancelled.)